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Guest Editorial

Therapy radiographer staffing for the treatment and care of cancer patients

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Abstract

Currently there is an acute shortage of therapy radiographers in the UK[1] at a time when radiotherapy referrals and workloads are rising[2] and most departments face waiting list pressures.[3] Concurrently, the scope for radiographer role extension both in the patient support and technical areas is widening. These factors have led to debate on the subject of staffing and testing of different staffing models as departments attempt to maximise the number of treatments that can safely be carried out per day while giving high quality patient support and holistic care.

Keywords

Skill mix; staffing; radiotherapy workloads; technology

There are many factors impacting on radiographer staffing and skill mix requirements for, and rapid technological developments in, radiotherapy.[4] The current computer driven technology requires operation by radiographers who are highly skilled in its application, using evidence based techniques. As technology and practice becomes more complex, more cognitive tasks per procedure are necessary and the potential for error is higher so there is a need for more specialisation and training. To keep pace with the continual developments, whilst safely maintaining treatment throughputs, an appropriate staffing structure allowing radiographer training time is required. Thus, the provision of adequate and safe radiotherapy services is fundamentally reliant on the availability of sufficient radiographers with expert skills in planning and delivering radiotherapy. If the staffing requirement for these core services is properly met, this will allow good patient care, optimise quality, and support role extension. These needs must be met to maintain safety, flexibility, support student training and provide skills for the future. The structure described allows these needs to be met within each linac or simulator/clinic team, with daily staff continuity to support the relationships with patients which form the basis for holistic support and care.

The needs of radiographers in terms of quality of working life, motivation, morale and personal development must also be considered as the current situation will not be resolved quickly and loss of staff from the profession will exacerbate the shortages.

A model found to be effective in a large centre with a full case mix including paediatrics, sarcoma, TBI, TBE and a range of complex technology and techniques is described and the effect of various factors discussed. The centre, with four Elekta linacs (two with MLC), three simulators (ranging from old technology to new), a cobalt unit, three afterloading units and a superficial unit, currently has a case mix specific to linac type, and to each simulator, because of the technical features and energy availability. This diversity complicates staffing and increases training loads.

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DEVELOPMENTS RELEVENT TO RADIOGRAPHER STAFFING AND SKILL MIX

Over the last decade or so, radiotherapy has evolved from a comparably simple process with limited success and high morbidity, using simple technology, to a highly curative lower morbidity treatment modality using complex technology. Radiotherapy alone, or in combination with surgery and/or chemotherapy, is now recognised as a key curative cancer treatment modality and will continue to make a significant contribution to improved treatment and palliative outcomes[2] for the foreseeable future. This evolution has a major effect on staffing and skill mix requirements, and necessitates IT and higher level technological skills as well as patient support skills.

The change to sophisticated computer driven technology and the associated skills revolution for radiotherapy seems not to have received specific recognition by the professional body in its published strategies.[5–7] This is in contrast to diagnostic radiology where the level of specialisation required is recognised[8] so that specialist post graduate training and qualifications are required to run CT and MRI units. That radiographers require a high degree of IT skills in both the imaging and equipment field is recognised for diagnostic work; 'the change in working practice due to technological advancement is perhaps more evident in radiography than any other paramedical profession'.[9] Yet, although accurate diagnosis is critical, the modalities and doses used are not dangerous in comparison to radiotherapy, where both treatment outcome (survival) and morbidity are highly dependent on the accuracy of treatment and the technique used.[10–15] This lack of recognition may be linked to the perception that treatment units other than linacs still have a major role in terms of treatment delivery workload,[16] or perhaps that computer technology simplifies practice.

In reality there is now little indication for orthovoltage, and the majority of Cobalt units have been, or are imminently, being replaced by linacs.[2] Superficial and afterloading units have an important role but for a very low proportion of the radiotherapy workload (combined these make up only 2% of fractions in this department which has a wide range of afterloading work). Therefore, since linacs are now used for the delivery of around 98% of radiotherapy treatments, their radiographer staffing, and that of simulation and planning services are key to the provision of safe radiotherapy and appropriate care to patients. Around 80% of the treatment planning and delivery workload at this centre is for patients for whom a cure is intended and there are few palliative patients treated on our linacs (this case mix will change slightly when our Cobalt unit is replaced by a linac).

The technical advances have allowed the development of more accurate techniques for planning and delivering radiation. The challenge for the team planning and delivering radiotherapy is to develop evidence based methods of ensuring that the tumour is accurately treated each day despite uncertainties relating to the patient anatomy being mobile.[17] This has led to continuous research and development in methods of patient positioning, set-up and equipment use[17–23] to ensure that accuracy can be achieved within a few millimetres, essential for conformal techniques. Methods must take into account the patient and their ability to undergo the technique.[17,18]

Linac technology and its application is increasingly complex and the scope for error increases with treatment and technology complexity.[24,25] The use of parameter verification systems together with portal image verification, are now appropriate for radical work.[26,27] Specialist skills are required for each of the technologies. Since tissue lethal radiation doses are administered, the potential for serious injury to patients exists if mistakes occur. Machine linked record and verify systems can lead to errors being systematically repeated on each treatment if used as an unchecked set-up system[27–29] and similar potential exists when parameters are transferred electronically. For electronic transfer, the treatment planning system and operator must configure parameters in the orientations used in treatment delivery for all the linacs used. This may not be easily achievable, especially where different machines with different diaphragm and wedging systems exist within the department. Pre-treatment checks are required to ensure the parameters agree with the reference document (prescription), whichever system is used, and so checks continue to have a radiographer staffing implications.

Complex parameter printouts, prescriptions, and treatments take longer to check than simple ones, with complex 3D cognitive visualisation of the intended set-up. Radiographers require spatial skills for perceiving three dimensional relationships, in order to position patients accurately[30] for treatment. Some treatment planning outputs contain little or no patient orientation information and thus checking and visualisation of treatment plan parameters against a simulator check film or DRR is required to assure the orientation of the parameters on the patient. This also involves being able to visualise the orientation of X and Y collimators at any collimator and gantry angle for the linac which the plan relates to, when looking at the linac from the foot of the treatment couch at zero angle. When two different linac makes are in use where X1, Y1 on one corresponds to Y2, X2 on the other, this confuses spatial assessments of parameter orientation as two complex mental data sets are in conflict.

Table 1 illustrates one complexity effect, that of the use of asymmetry using offset or independent diaphragms, which, while introducing benefits, increases set-up and checking complexity for each treatment field. All the parameters shown in Table 1 have an inter-relationship so the correct orientation of each is dependent on each of the others.

Thus, the technical roles critical to curing patients have diversified and the skills required to ensure treatment is delivered accurately have undergone radical change. The increased taskload per patient to achieve this makes extra radiographer time necessary for each treatment. In terms of device safety, the Medical Devices Agency safety bulletin stresses that user knowledge and skills have major implications for safety and that both generic and model specific training are needed: 'well-maintained equipment used by well trained staff minimises risks; in the event of an adverse incident, discovery of failures in training or maintenance may lead to a finding of liability by courts'.[31] Training in each technique and technology new to the individual is required by the COIN guidelines for external beam radiotherapy.[27]

Radiotherapy practice is also evolving in a way which increases the diversity and complexity of techniques. There are numerous protocols in use each day, including various radio-chemotherapy regimes which add both to the complexity and criticality of the daily practice and to the logistics and liaison involved in organising patient schedules as the correct daily timing of radiotherapy with chemotherapy is crucial.

Table 1. Set-up checks per field for symmetric and asymmetric practice.

Symmetric practice	Asymmetric practice
3D patient position	3D patient position
Gantry angle	Gantry angle
3D field/isocentre position	3D field/isocentre position
Wedge orientation	Wedge orientation
Diaphragm angle	Diaphragm angle
Shielding orientation	Shielding orientation
X field axis size	X1 field axis size
	X2 field axis size
Y field axis size	Y1 field axis size
	Y2 field axis size
X axis orientation to patient	X1 orientation to patient
	X1 -ve or +ve value
	X2 orientation to patient
	X2 -ve or +ve value
Y axis orientation to patient	Y1 orientation to patient
	Y1 -ve or +ve value
	Y2 orientation to patient
	Y2 -ve or +ve value

Simultaneously, the information and support needs of patients before, during and after radiotherapy have been increasingly understood and met. Here too the roles of radiographers have diversified and widened. The radiographers treating patients each day are best placed to give support via the relationships they develop with patients, which inform their assessment of the patients needs.

Radiotherapy workload increases are continual. Increases in machine use per patient, related to increased quality and complexity (e.g. a rise of 18.5% in exposures in the five years 1992–97) are predicted to continue.[2] In addition, there will be increased referrals per unit population associated with the Calman-Hine initiative[32] and increases in the elderly (at risk) population. Health policy and government priorities for cancer will increase referrals.[33] The potential safety risks associated with high radiotherapy workloads for staff (treatment and simulation) are recognised[2] so radiographer staffing must be appropriate to workload and the functions undertaken.[27]

There is a need to compensate for gaps in treatment which would otherwise jeopardise the treatment outcome for some categories of patient.[34] This also has a staffing consequence and affects the management of workload during breakdowns and servicing, with a consequent need to extend the day or work at weekends.

EFFECT OF STAFFING LEVEL ON PATIENT CARE AND RADIOGRAPHERS

Inability to run to full capacity leads to increased waiting times. High quality patient care is jeopardised if the overall establishment of radiographers is too low to consistently staff all services. All functions then become pressured and it becomes difficult to find sufficient time for:

- Staff review and appraisal.
- Continuing professional development activities.
- Multidisciplinary meetings etc.
- Role development.
- Service development.
- Protocol and practice reviews.
- Training.

Many of these activities are key components required for clinical governance. There is difficulty in moving staff between specialties/machines in order to provide all round experience and flexible cover, if the need for them to train on each (as partially supernumery for a period)[27] cannot be met.

These factors could have an adverse effect on morale, motivation, recruitment and retention of staff in the profession, exacerbating existing shortages, in addition to limiting the quality of patient care. Under these conditions, particularly for those in senior positions, providing family friendly working patterns is difficult, except for jobshare arrangements. Working conditions may also be a factor affecting recruitment and retention in the profession, and have been considered in planning staffing and working patterns in this centre.

BASIC CONCEPTS FOR THE STAFFING MODEL

The size, equipment base and case mix of a centre may influence detail of the staffing model adopted, but not the basic concepts. The department staffing as a whole must to be able to support all the functions carried out by radiographers, to meet the workload demands and patient care needs. Enough cover at each grade for absences is essential and the model must provide for career structure/career progression to maintain viability of the profession for the future.

Therefore the factors to be catered for within the staffing model include:

- Holistic patient care and support.
- High quality of service.
- Optimum throughput.
- Technical complexity.
- Technical quality.
- Specialist practice.
- Radiographer inter unit/specialty training.
- Continuing personal development and appraisal.
- Ongoing research based practice development.
- Robustness of service.
- Safety – technical and manual handling.
- Student training.
- Role extension.
- Protocol and service development.
- Service and staff management and forward planning.
- Quality assurance and risk management.

These factors are taken into account in the model described.

SPECIALIST PRACTICE AND STAFFING IMPLICATIONS

Range of practice

All of the treatment practice and associated planning functions require specialist radiographer skills to be undertaken effectively. The greater the range of radiotherapy services provided, the greater the range of specialist practice required of radiographers.

Specialist linac practice

Complex practice, equipment and techniques increase radiographer training for staff moving between different linacs with different caseloads. Successive linac models have extra technological capabilities and different software. The operating system concepts, software language, parameter labelling and controls vary with manufacturer. Linac operation is increasingly complex and different linac technology/features and beam energies result in a specific case mix related to

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certain linacs unless all the linacs in the department are the same. When linacs with differing technology are purchased, the learning curve for the first machine of the type can extend over a year or two during which the throughput will increase. Staff moving on to the unit will need a significant training period (longer, the higher the grade and the responsibility being taken).

Where the case mix is machine specific, radiographer skills are specialised to a particular linac and it's case mix at any point in time. Efficient and safe treatment delivery is dependent on the radiographers having a comprehensive and complex, linac specific, mental data set on instant recall to integrate with patient specific data sets. This integrated data is used in intricate mental, correlated with physical, activities. These mental and physical processes have to be executed both rapidly and frequently throughout the clinical session, in conjunction with patient care.

Staff moving to another unit thus require semi-supernumery time to learn about the operating systems; software and features of the equipment; the techniques and practice specific to the unit; the individual patients and their treatment set-ups (visual knowledge included). The staffing must allow this to support the learning and avoid extra stress for others in the team.[27] The number of training weeks needed is proportionately more for those working part-time hours since they will require the same number of hours training. Semi-formalised training programmes are facilitated by the superintendent on the unit.

Linac staffing, taskload and skill mix

A high level of radiographer patient continuity is required for good patient support[26] and effective treatment delivery so the working patterns must allow this continuity. The various treatment and patient care related activities undertaken each day by each linac team, are separate from, but essential to, delivering a continuous flow of treatments throughout the day. With five radiographers, several tasks can be undertaken simultaneously, optimising the treatment flow by avoiding these support tasks protracting, delaying and interrupting treatments.

New patient treatment checks and data programming are needed daily in addition to the weekly checks for each patient. These checks require radiographer time and to be completed thoroughly require as much radiographer time per day as is devoted to treatment delivery. They may be undertaken in a separate location but are undertaken by the linac team involved in the delivery of the treatments, to allow the highest degree of safety as well as role completeness for the team.

Where practice is specialised to each machine, training of students and staff is a continuous activity, and one or more of each team will always be learning. Having five radiographers per linac throughout the day allows for some to be delivering treatment while others undertake patient care, training (staff and students) and technical tasks. Two radiographers must be involved in setting up and delivering each treatment in the room,[40] both to provide two independent checks and for speed. Most set-ups are not feasible to achieve efficiently without two radiographers who are experienced in the particular technique. They must have the expertise to detect problems with the set-up, the equipment, or the patient and be competent to make the required judgements.

Regular short breaks are essential as delivering radiotherapy is continually highly demanding both mentally and physically and most of the tasks are critical to quality and radiation safety. When only two staff are available during breaks, interruptions, phone calls etc can slow the work, and there is a conflict between throughput and having time to speak to each patient. This results in treatment delivery being delayed or protracted whilst talking to the patient and leads to sub optimal patient support as the patient perceives the lack of radiographer time. This is a safety issue as information relevant to the treatment or care needs may be withheld, as well as a patient care and radiographer job satisfaction factor. Having a fifth radiographer in the team helps with efficiency and patient care throughout the day because more tasks can be undertaken simultaneously. This may allow as many patients to be treated per eight or eight and a half hour day as the same five radiographers could treat if covering a longer working day between them as the team can continually:

- Provide high quality patient care/support.
- Undertake all the safety and verification checks.
- Maintain patient throughput.
- Undertake and receive training.

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Staff development and appraisal are also feasible as there is some scope for radiographers to leave the linac occasionally.

Complexity and specialised practice require each linac to be run permanently by a specialist clinical/technical Superintendent III for the case mix and technology, to increase the safety of treatments and:

- Participate in the daily practice.
- Train and develop staff on the unit.
- Provide expert knowledge to troubleshoot problems with the linac/computer system.
- Participate in specialist practice developments.
- Enable optimum efficiency.
- Facilitate multidisciplinary teamwork.
- Participate in and train the team in site specialist patient care and support for the types of cases treated.

The team should also include a Senior I, a Senior II and two radiographers, plus additional Senior cover for leave. This skill mix allows a senior with the appropriate skill level to participate in every treatment procedure and every check process.

One helper per two linacs can deal with non technical administrative tasks, telephone calls, appointments/reception/general liaison with transport etc. This frees radiographers to undertake technical and patient support tasks without constant interruption. More non-treatment tasks can be undertaken if there is one helper per linac.

Helpers are valuable members of the team who free-up radiographer time for technical and patient support tasks, but do not undertake set-up or irradiation. The suggestion by the professional body of a technician grade in Oncology[35] for 'routine protocol driven tasks', appears now to include set-up and irradiation tasks. However, a technical worker has been defined as having a 'narrow, task driven skills set probably restricted to one procedure'.[36] The demise of orthovoltage and Cobalt units in most centres has removed any element of regular simple or 'routine' work from radiotherapy treatment practice. Bearing this in mind and the complexity described earlier, the role of a technician in providing safe, high quality radiotherapy treatment is unclear since our skill mix must allow us to maintain and continue to improve standards of patient care.[37]

Linac staffing and treatment workload achievable

The national average[2] of 20,000 exposures per annum per linac in 1997 was mainly achieved using four WTE radiographers per day per linac. Whilst it is undesirable to maintain very high workloads per machine, the current situation requires optimal use to be made of available equipment within service quality and safety constraints. The RCR found that in 1992 compared with 1997 a 17.6% increase in treatment workload was achieved via 18% more radiographers being involved in treatment delivery (the overall UK equipment base remained virtually the same).

In our experience around 45–55 treatments per eight or eight and a half hour day may be achieved with 5 radiographers of the described skill mix working each day per linac (also undertaking patient care in separate rooms), for the following types of case:

- Routine pelvis and chest.
- Breast.
- Routine/relatively simple head and neck techniques.
- Electrons.

The more complex matched junction head and neck work, conformal, paediatric work and TBI take longer per fraction. This reduces the number of fractions achievable by around 10–20% for a linac where this case mix makes up the majority of the work.

These workloads are achievable on a linac with MLC, portal imaging and verification systems, once staff are fully trained and have developed an effective system of work. However, maintaining the throughput requires a machine specialist superintendent who is expert with the technology and techniques. Without this specialist the workload achievable will be lower and reduced further with fewer radiographers.

Working patterns, treatment safety and workload

Where the radiotherapy demand is higher than the resource provision, waiting list pressures have led to a longer working day in many centres. A working day extended by more than half an hour

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or so would require more radiographers per linac each day to increase the overall throughput.[2] The same number of radiographers is required at any time, i.e. per shift in order to keep up throughput and the associated activities, a concept consistent with the pre-existing (1979) staffing recommendations.[38] The high level of cognitive tasks continually undertaken can only be effectively maintained for a limited period each day. The effect of fatigue after more than eight hours continuously undertaking this together with physically demanding work may be considered to be an unacceptable risk. In addition breakdowns or delays extend the length of shift in an ad hoc manner, which should be recognised when planning working hours.

Extended day working is fully discussed elsewhere[39] and is acknowledged to be an option which leaves little flexibility for patient transfer during breakdowns and equipment replacement. This means that managing or preventing gaps during the week is less practical and this may result in a regular weekend workload. Changes in skill mix and patterns of working cannot solve the problem of underprovision.[2]

STAFFING FOR OTHER KEY ONCOLOGY FUNCTIONS

Simulation and planning

Each simulator requires similar staffing to a linac, but with four radiographers to achieve optimal equipment utilisation if there is a high workload (this assumes liaison with additional planning and mouldroom staff). Specialist skills in marking up breast patients are required. A helper in each simulator team undertaking film processing, administration, chaperoning, transport liaison etc. allows radiographers more time with patients.

Clinics

At this centre, Consultant Oncologist planning clinic sessions are each run by radiographers to enhance patient information and support during planning. Helpers assist in the clinics and undertake administration. Radiographers also attend peripheral clinics for some groups of patients so as to provide information and patient centred care from referral through to treatment. They work collaboratively with other professionals with expertise for the patient group. Currently this is a pilot scheme and it is hoped to expand it to other patient groups as and when more posts are available.

Patient scheduling

Scheduling is complex in this large centre with a mixed range of linacs with specialised case mixes, even using a comprehensive computerised system, requiring skilled radiographers at Senior level. They work in liaison with a team of helpers undertaking the patient administration work, and with Superintendent IIIs as necessary.

Brachytherapy

Even with a relatively high workload as in this centre, afterloading brachytherapy treatments are intermittent so can be staffed to meet sessional needs. Specialist skills and therefore training are required for this work also, especially where three different afterloading machines and different dose-rates are in use.

Management team

The radiographer heading a department, has regional and national duties key to strategic service and professional viability for the future, in addition to Trust, Cancer Centre and administrative roles, all of which are time consuming. Management of services and high level input to student training and pre and post registration education are also key roles and together with the associated regional and national work can involve regular time out of the department.

Thus the deputy head is essentially the operational manager directing service developments, ensuring that there is overall service co-ordination, and working with planners for equipment replacement, building schemes etc This role is key to ensuring that developments in one area are integrated within the service as a whole, and that timely and appropriate training is available to support all service developments.

In a large department with a wide range of services (e.g. 6 linacs, 3 simulators, clinics, afterloading) which takes on rapid technical and service developments, further high level expertise and time is required to keep pace with the work this

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requires. This can be provided by sections of the department and their specialised services being headed by a Superintendent II who is a clinical/technical expert. Their role is closely linked with that of the head and deputy, in helping to take forward developments with clinical staff and in evolving evidence based, protocol driven practice, the time for which is not feasible for the Superintendent IIIs with a daily clinical caseload and specialist roles. The role allows expert clinical cover at any level including when the Superintendent III for a unit/service is on leave and includes intermittant clinical work and:

- Radiation/safety supervision for the services in their section.
- Technical developments including the design and implementation of training packages and programmes for new developments for their section, with the Superintendent IIIs.
- Undertaking staff reviews and CPD for a proportion of the departmental staff group, in conjunction with the Superintendent IIIs and Senior Is.
- Working with others to ensure co-ordinated team-working and consistency of protocol/practice/development across the department.
- Leading on, e.g. CPD activities, research and development, technical or IT development, audit, health and safety etc. for the department.
- Recruitment and selection in conjunction with Superintendent IIIs and Senior Is.

Staffing structure

Extra staff are required for annual leave, in addition to lieu time, CPD time, and time owing for on-call work and late finishes etc. Some maternity leave can be accommodated within the establishment if appropriate cover is built in. In addition there will be a minimum of 3% sick leave to cover. These equate to a need for an average additional 20–25% cover to be provided below Superintendent III level. Within this figure some cover for Superintendent III leave is provided at Senior I level, the remaining cover being from Superintendent IIs.

The staffing described is broadly consistent with the 1979 College of Radiographers/Royal College of Radiologists staffing recommendations,[38] which, although updated to reflect current roles, responsibilities and workloads,[2] is quite comprehensive as a framework. Even in 1979 a simulator or linac required a Superintendent III, and a Superintendent II was required to run a section of a department. The recommendations were for an average workload and stated that extra staff were required for high workloads, training functions, and cover for leave.

Additional clinical specialist posts exist in this centre specifically for:

- The continual enhancement of patient friendly services and outreach support and education of other professionals in cancer care (Macmillan radiographer).
- Clinical lecturer based in the NHS to enhance student support and training.
- Imaging research post to develop expertise with imaging modalities and analysis tools and facilitate radiographer image evaluation and decision making.

CONCLUSION

Radiographer staffing has a complex inter-relationship with workload, equipment, technology, specialist practice, range of practice and roles. Patient care and effective utilisation of technology are dependent on the staffing structure. The structure described supports the development of evidence based, high quality clinical practice and patient friendly services whilst facilitating the necessary staff development and training to equip staff for continually changing technology and practice.

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